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AN EVALUATION OF OZONE INJURY TO PINES ON THE ELDORADO NATIONAL FOREST

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ABSTRACT

Forest Pest Management personnel conducted an ozone injury survey on the Eldorado National Forest in October 1982. In addition, ambient ozone dosages were monitored at the Georgetown Ranger Station, and at the California Department of Forestry Fire Station at Arnold.

Ozone injury was found to be light and was generally scattered over the Forest. About 50 percent of the plots had trees with symptoms, but only 14 percent of all trees on these plots had oxidant symptoms.

The California State Standard for ozone (10 parts per hundred million) was exceeded 21 times at the Georgetown Ranger Station and five times at the Arnold CDF Station. The Federal Standard for ozone was exceeded only once at Georgetown. It was not exceeded at Arnold.

The ozone injury survey showed that there were fewer trees with foliar symptoms on the Eldorado National Forest than on the Stanislaus National Forest surveyed in 1981.

INTRODUCTION

Ozone injury symptoms have been reported on pines in the Sierra Nevada of central California since 1971 (Miller and Millecan, 1971). The status of ozone injury in the southern Sierra Nevada has been followed by the Forest Pest Management (FPM) Staff since 1974.

In 1981, the Forest Pest Management Staff, began to describe and assess the air pollution situations in the central Sierra Nevada using ozone injury ground plots and ozone dose monitoring. The Stanislaus National

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Forest was found to have slight ozone needle injury scattered at low to mid elevations in a 1981 survey (Allison, 1982).

OZONE INJURY GROUND SURVEY

In October and November 1982, the FPM Staff conducted a ground survey of ozone injury to pines on the Eldorado National Forest. The survey was designed to identify sites where ozone symptoms were present or absent on ponderosa and Jeffrey pines, to identify any other pests affecting these pines, and to determine the actual extent of ozone injury. Only these two pine species were included because they are the conifers most sensitive to ozone injury in California.

Ozone symptoms include a characteristic chlorotic mottle on the needles of affected pines in addition to reduced needle length and reduced needle retention. The ozone symptoms appear first on the oldest needles and lowest branches, and with increasing injury, progress to the younger needles and upper branches. We distinguish between injury and damage in the following way: injury includes any abnormal changes in the appearance or function of a tree, whereas damage involves a measureable decrease in growth or economic value of a tree. We did not collect growth data during the survey, and therefore, our comments are restricted to levels of visible oxidant injury and not to measured amounts of tree damage.

Methods

Potential plot sites were systematically selected so there would be one plot per township within the Eldorado National Forest. Plot selection was made in consultation with both the Forest and District silviculturists because they would know if the plots would meet our plot selection criteria in terms of size and numbers of trees and accessibility. Plot sites were considered valid if ten ponderosa and/or Jeffrey pines were found within an area one chain (20 meters) by six chains (121 meters) on each side and parallel to the road. The near edge of each plot was separated from the roadside by one-half chain (10 meters). Within each plot, various site and tree characteristics were observed. Some of the important site data collected included plot elevation, location, aspect, topography, and slope; and stand type, size class, and density. Tree data collected included species, dbh, crown position, live-crown ratio, other pests present, and ozone injury rating. Pest data was collected to avoid confusing other abiotic or biotic symptoms with ozone injury.

Ozone symptoms were evaluated and rated by examining branches from the lower crown of each tree. The scoring system used is described in Table 1. It is based on the severity of chlorotic mottle present on pine foliage. Pines with symptoms were given a score between 0 and 4, the number indicating how many years of retained needles were healthy or free of mottle. Trees with no symptoms and trees with symptoms on fifth year or older needles received scores of 4. The 10 individual tree scores were averaged to yield a plot score, and the overall injury level for each plot was described as listed under "Extent of Injury" in Table 1.

ELDORADO NATIONAL FOREST

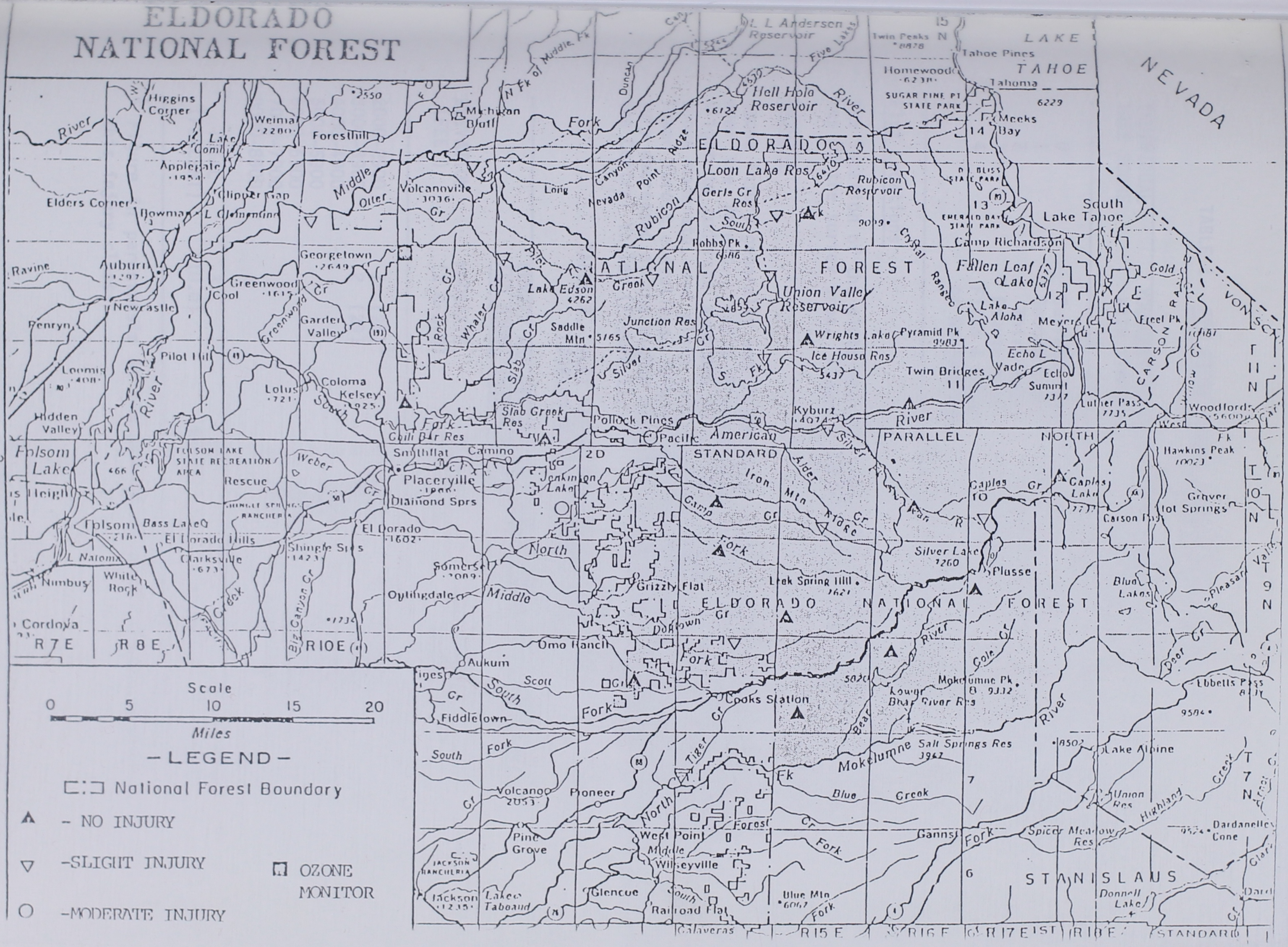

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TABLE 1. FPM OZONE INJURY SCORING SYSTEM FOR PINES.

INDIVIDUAL TREE SCORE	YOUNGEST NEEDLES WITH SYMPTOMS	AVERAGE PLOT SCORE	EXTENT OF INJURY
0	Current Year	0 - 0.9	Very Severe
1	Second Year	1.0 - 1.9	Severe
2	Third Year	2.0 - 2.9	Moderate
3	Fourth Year	3.0 - 3.9	Slight
4	Fifth & Older or No Symptoms	4.0	None

Plot Locations

The location of the plots and the ozone injury ratings were placed on a map of the survey area. Figure 1 was drawn from this map.

Results

Ozone injury generally was found to be slight and was scattered widely over the forest. Table 2 shows that 50% of the 30 plots exhibited slight to moderate symptoms of oxidant injury. No plots had ratings above moderate, and plots with moderate injury were found only at the lower forest elevations, between 2000 and 3900 feet. The level of injury decreased at the higher elevation and in areas further removed from the Central Valley (Figure 1).

TABLE 2. PLOT RATING FOR OZONE INJURY ON THE ELDORADO NATIONAL FOREST, 1982

	NUMBER AND PERCENT OF SAMPLING PLOTS BY ELEVATION AND OZONE INJURY RATING			
ELEVATION (FEET)	MODERATE (2.0-2.9)	SLIGHT (3.0-3.9)	NO SYMPTOMS (4.0)	TOTAL
2000-2900	1 (25)[1]	1 (25)	2 (50)	4
3000-3900	2 (29)	4 (57)	1 (14)	7
4000-4900		3 (38)	5 (62)	8
5000-5900		2 (40)	3 (60)	5
6000-6900		1 (50)	1 (50)	2
7000-7900		1 (33)	3 (67)	4
8000-8900		0	0	0
TOTAL (PERCENT)	3 (10.0)	12 (40.0)	15 (50.0)	30 (100)

[1] Figure in parenthesis is the percent of trees of this evaluation in this injury class.

The amount of damage being done to the ponderosa and Jeffrey pines by ozone is unknown. In our estimation trees with symptoms on fourth-year or older needles (slight and no symptoms ratings) are probably not suffering appreciable growth loss, and these two categories account for 90 percent of the trees (Table 3). The remaining 10 percent of the trees were rated to have moderate or severe injury. Normally between 60 and 80 percent of the total photosynthetic activity of ponderosa pines lies with the first and second-year needles (Freeland, 1952, Helms, 1970). It is possible then, that pines with oxidant injury on third-year and older needles are suffering some slight growth reduction.

Although none of the survey plots was rated to have more than moderate injury, some points should be kept in mind. Sample plot scores are the averages for ten trees, and pines vary greatly in their sensitivity to ozone. Within some moderate and even slight injury-rated sample plots, there were individual trees with oxidant symptoms on second-year needles and with only two years of needle retention. These trees are obviously growing under stress. Table 3 shows that about 14 percent of the trees examined showed foliar ozone symptoms and none had symptoms on current year's needles, however over half these trees were moderately or severely affected.

TABLE 3. THE NUMBER AND PERCENTAGE OF INDIVIDUAL PONDEROSA AND JEFFREY PINES BY OZONE INJURY RATING, ELDORADO NATIONAL FOREST, 1982

(TOTAL TREES = 300)

TREE RATING	NUMBER OF TREES	PERCENT TREES
No Symptoms (4)	259	86.3
Slight (3)	11	3.7
Moderate (2)	14	4.7
Severe (1)	16	5.3
Very Severe (0)	0	0.0
Total	300	100.0

Associated Insect and Disease Pests

The insects most frequently observed on the surveyed pines were pine needle scale (*Chinospis pinifoliae*) and aphids (*Cinara* spp.). Dwarf mistletoe (*Arceuthobium campylopodum*), and western gall rust (*Peridermium harknessii*) were the most commonly encountered tree diseases.

Discussion

Table 4 compares symptoms of oxidant injury on plots and individual trees between the Eldorado and Stanislaus National Forests. The 50 percent of plots exhibiting symptoms of oxidant injury on the Eldorado is much lower than the 83 percent of ground plots exhibiting symptoms of oxidant injury on the Stanislaus or the 79 percent combined results of injury trend plots evaluated on the Sierra and Sequoia National Forests in 1979/80 (Pronos and Vogler, 1981). In the southern Sierra Nevada, plots with moderate injury were found at all elevations except 8000 feet. This differs markedly from the Eldorado where all plots with moderate injury were found at elevations less than 4000 feet or the Stanislaus where all plots with moderate injury were found at elevations less than 5000 feet.

Table 4 also shows that about 86 percent of the individual trees on the Eldorado had no oxidant symptoms, while 70 percent of the trees on the Stanislaus had no symptoms.

TABLE 4. OZONE INJURY RATINGS OF PLOTS AND INDIVIDUAL TREES ON THE STANISLAUS AND ELDORADO NATIONAL FORESTS.

NATIONAL FOREST	PLOTS A[1]	B	C	D	E	INDIVIDUAL TREES A[2]	B	C	D	E
Eldorado 1982	0	0	3	12	15	0	16	14	11	259
Stanislaus 1981	0	0	7	31	8	2	29	73	32	324

[1] A = Very Severe, B = Severe, C = Moderate, D = Slight, E = None

[2] A = Very Severe, B = Severe, C = Moderate, D = Slight, E = None

Conclusions

Ozone symptoms are common and widespread in much of the southern Sierra Nevada. The Eldorado survey indicates that ozone symptoms are less common and not as widespread as on the forests to the south in the Sierra Nevada.

Our ozone surveys have shown that ozone symptoms are decreasing as we move farther north in the Sierra Nevada. However, the northern extent of ozone injury will not be known until ozone surveys are conducted on the Tahoe and perhaps other forests in the northern Sierra Nevada. Although ozone injury symptoms are readily found on the Eldorado, ozone is not presently causing significant damage to pines on a forest-wide basis.

OZONE MONITORING

The Forest Pest Management (FPM) Staff began measuring ozone levels at selected sites in the southern Sierra Nevada in 1976. In 1982 the FPM Staff conducted season-long (May-October) monitoring at the Georgetown Ranger Station, Eldorado National Forest (3000') and the California Department of Forestry Fire Station at Arnold (4000') in the central Sierra Nevada. The ozone monitoring sites are shown in Figures 1 and 2.

Methods

Ozone concentrations were measured with Dasibi ozone monitors calibrated by the state of California Air Resources Board and maintained by the FPM Staff, California Department of Forestry, and Eldorado National Forest. Ambient air samples are collected through Teflon tubing with sample inlets located 20 to 26 feet (6 to 8 meters) above the ground level. Span frequences were set to compensate for elevation according to Air Resource Board specifications.

Results and Discussion

Comparable ozone data from Georgetown Ranger Station, Eldorado National Forest and from California Department of Forestry Fire Station at Arnold are shown in Table 5. Results from Table 5 show that ozone levels in the central Sierra Nevada do not approach the levels recorded in the southern Sierra Nevada (Vogler, 1982).

The maximum hourly averages and the means of the daily maxima at Georgetown were approximately the same as those at Arnold. The lower ozone dose in the central Sierra Nevada when compared to the southern Sierra Nevada corresponded to a similarly lower level of injury to pines.

The California State Standard (10 parts per hundred million) was exceeded 21 times at Georgetown Ranger Station and 5 times at Arnold, California Department of Forestry (Tables 6-7). These two table show that the State Standard was exceeded in June, July, and August at Georgetown and in June and September at Arnold. The Federal Standard for ozone (12 parts per hundred million) was exceeded only once at Georgetown in July. The Federal Standard for ozone was not exceeded at Arnold (Table 6-7).

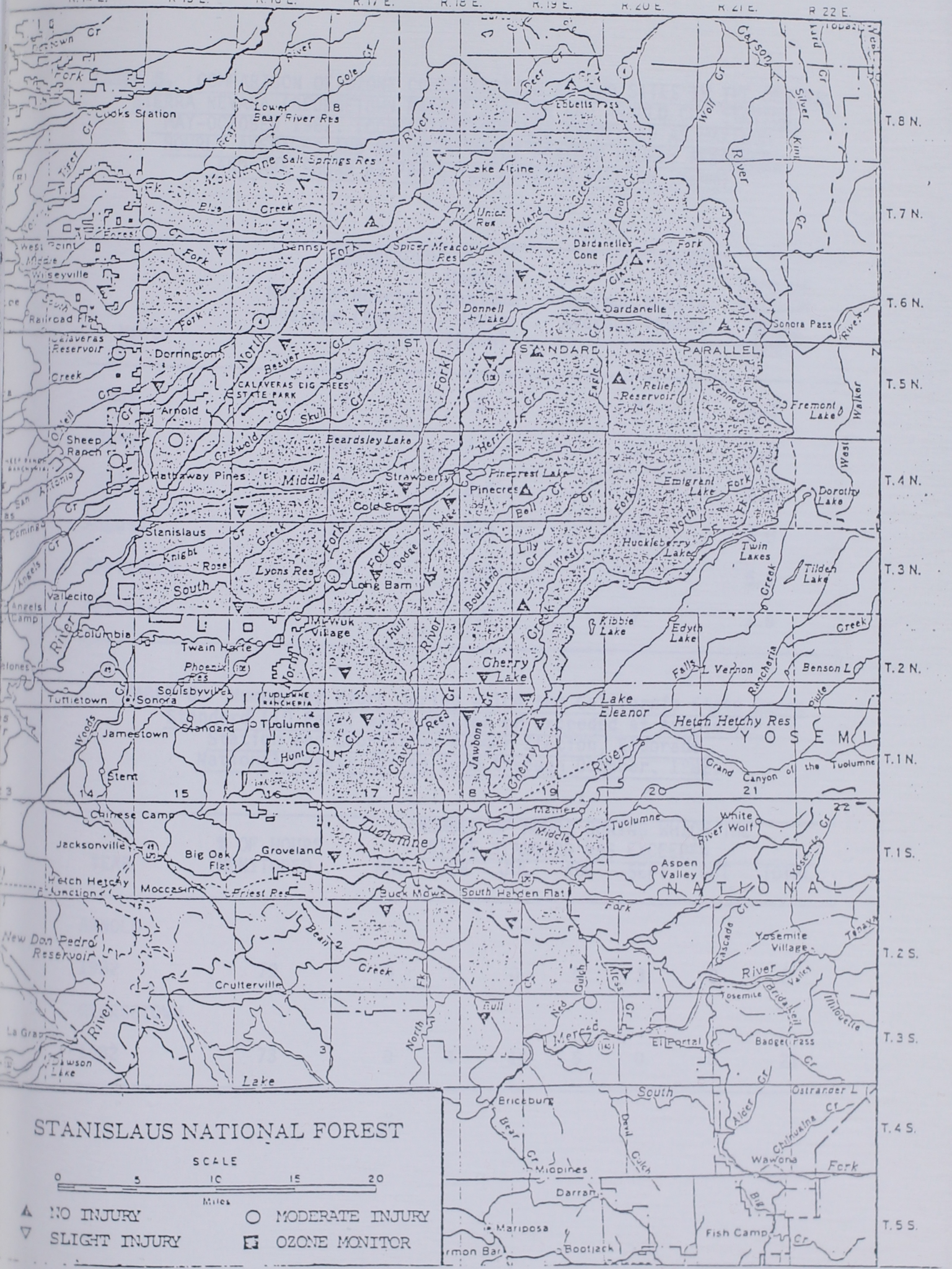

Figure 2. LOCATIONS AND RATINGS OF OZONE INJURY SURVEY PLOTS ON THE STANISLAUS NATIONAL FOREST, 1981

TABLE 5. COMPARISON OF OZONE CONCENTRATION AT TWO SITES IN THE CENTRAL SIERRA NEVADA (GEORGETOWN RANGER STATION AND ARNOLD CDF STATION, MAY-OCTOBER 1982. (CONCENTRATIONS ARE EXPRESSED AS MAXIMUM HOURLY AVERAGES AND MEANS OF DAILY MAXIMUM HOURLY AVERAGES, AND ARE SHOWN AS PARTS PER HUNDRED MILLION (Pphm).

	Georgetown		Arnold	
Month	Maximum Hourly Average (Pphm)	Mean Of Maximum Hours (Pphm)	Maximum Hourly Average (Pphm)	Mean Of Maximum Hours (Pphm)
May	7	6	7	6.3
June	10	7.0	11	6.5
July	14	8.5	9	7.0
August	13	8.5	10	7.0
September	9	5.0	15	6.0
October	8	4.0	7	5.5

TABLE 6. Number of Hours during which the California State Ozone Standard (10 Pphm) was equalled or exceeded at Arnold CDF Station and Georgetown Ranger Station, Eldorado National Forest during June through October, 1982.

YEAR	% OF HOURS MONITORED	NUMBER OF HOURS DURING WHICH THE STATE STANDARD WAS EXCEEDED						
		MAY	JUN	JUL	AUG	SEPT	OCT	TOTAL
ARNOLD								
1982	79	0	2	0	0	3	0	5
GEORGETOWN								
1982	73	0	4	12	5	0	0	21

TABLE 7. Number of Hours during which the Federal Ozone Standard (12 Pphm) was exceeded at Arnold CDF Station and Georgetown Ranger Station, Eldorado National Forest during June through October, 1982.

YEAR	% OF HOURS MONITORED	NUMBER OF HOURS DURING WHICH THE FEDERAL STANDARD WAS EXCEEDED						
		MAY	JUN	JUL	AUG	SEPT	OCT	TOTAL
ARNOLD								
1982	79	0	0	0	0	0	0	0
GEORGETOWN								
1982	73	0	0	1	0	0	0	1

Conclusion

We conclude that (1) ozone symptoms are common but not as widespread nor as intense in the central Sierra Nevada as they are in much of the southern Sierra; (2) ozone is causing only slight needle injury on a forest-wide basis; (3) localities with moderately-injured pines do exist; (4) the worst injury found was located along major river drainages or in the foothills at elevations less than 4000 feet adjacent to the Sacramento Valley; and (5) ozone injury is not severe enough to be causing much damage or loss in the Eldorado National Forest.

Our monitoring in the central Sierra Nevada to date has shown a decrease in ozone concentrations as you move from the southern Sierra to the Stanislaus and Eldorado National Forests. The northern extent of smog symptoms will not be known until ozone surveys are conducted on the other forests in the northern Sierra Nevada.

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